nuclei have fused, two centres appear in the egg, each with radii—the required bi-polarity is established. The exchanges and movements in the protoplasm are then followed; the result is that certain constituents accumulate to excess in the equator between the two radiating centres, or "suns." The chief points are illustrated by diagrams. The two "suns" are the centres of the future daughter-cells; the still single nucleus lies between them in a bridge of the same protoplasm as the "suns" (these "suns," by the bye, are the *Attractions-Kugeln* of Van Beneden, and the *Pol-Kugeln* of others) are embedded in: the more peripheral protoplasm of the cell (ovum) has accumulated chiefly around the nucleus—*i.e.* in the equatorial plane. This equatorial protoplasm then begins to cut in two the nucleus, which has assumed the "karyokinetic" condition. Passing over many details, we may sum up the explanation shortly. The superficial shells of protoplasm are assumed to put forth pseudopodia between the "suns"—*i.e.* the author regards it as fundamentally a wetting process, due to changes at the surfaces. The processes are essentially of the same nature in vegetable cells, though it is impossible in a short space to summarise Berthold's discussion as to the relative importance of the numerous details which occur in different cases. Obviously the stumbling-block which is best worth further attack is the origin of bi-polarity in a spherical mass: that Berthold's suggestions do not satisfy the requirements will probably occur to everyone. The explanation offered to account for the complex karyokinesis cannot be regarded as fully satisfactory. At the same time some advantage may accrue from the new lights in which he puts the central figures of cell-division. We are here only half through the book however, and must proceed, confining our remarks still more closely.

Chapter VII. treats of the cell-network of plants, and the directions of cell-divisions, &c. It is in great measure a criticism of Sachs's celebrated view of the structure of the higher plants, and deals at some length with several of his positions. Of course, Berthold assumes primarily that the plant is to be regarded as chambered—cut up into cells, not built up of them. Two main principles are then employed. (1) The cell-divisions are, as a rule (at least in growing-points, &c.), halvings—*i.e.* each daughter-cell has the same cubic contents. This leads to a discussion of very many cases. Of course the shape of a segment does not forthwith enable us to judge of its relative contents, and difficulty occurs sometimes on this account: it is impossible to summarise the remarks, and especially since reference to the figures is necessary. (2) The second fundamental principle is that which regulates the position of fluid lamellæ elsewhere—the principle of least areas. The rule is that the new cell-wall takes such a direction that its area is the smallest possible. There are exceptions, *e.g.* cambium cells; but at least one feature appears to indicate a tendency to follow the principle—cell-walls never abut in the angles of cells. Sachs's law of rectangular division is comprehended as a particular case of Berthold's more general law: it fails where simultaneous divisions result in the formation of polygonal cells—*e.g.* in the embryo-sac—with walls inclined at angles greater than the right-angle.

The eighth chapter deals with the sculpturing on the interior of cell-walls, and allied phenomena; while Chapter IX. (the last) is devoted to "free cell-formation."

Enough has been said to show the wide scope of the book, though full criticism of it will only be possible after some of Berthold's test-cases have been worked over. Of course, from the nature of the work, it is open to the charge of being transcendental; but at the same time it must be allowed that we are getting into serious difficulties with protoplasm, and good, bold, shaking criticism is beneficial. In any case, several investigators will, no doubt, have something to say to Berthold's statements, for there is no lack of observations, old and new, as well as hypothesis, in the book we dismiss with this short review.

H. Marshall Ward

ON THE EXPLOSION OF METEORITES

We have received from M. Hirn a *tirage à part* of a communication to *L'Astronomie*, in which he discusses the various phenomena accompanying the explosion of meteorites, with a view to explaining their causes.

M. Daubrée, a long time ago, pointed out how very striking and difficult of explanation the noises are which are often heard in connection with the passage of meteorites, and called in question the explanation which had been given of their being really due to a veritable explosion.

M. Hirn, in his paper, begins by considering the causes which are at work in the production of the thunder which accompanies electric discharges, and of this he writes as follows:—"The sound, which we call thunder, is due, as everybody knows, to the fact that the air traversed by an electric spark, that is, a flash of lightning, is suddenly raised to a very high temperature, and has its volume moreover considerably increased. The column of gas thus suddenly heated and expanded is sometimes several miles long; as the duration of the flash is not even a millionth of a second, it follows that the noise bursts forth at once from the whole column; but for an observer in any one place it commences where the lightning is at the least distance. In precise terms, the beginning of the thunder-clap gives us the minimum distance of the lightning; and the length of the thunder-clap gives us the length of the column. It must be remarked that when a flash of lightning strikes the ground, it is not necessarily from the place struck that the first noise is heard." M. Hirn then gives an interesting case which proves the truth of this remark. He next points out that a bullet whistles in traversing the air, so that we can to a certain extent follow its flight; the same thing happens with a falling meteorite just before striking the earth. The noise actually heard has been compared to the flight of wild geese or the sound produced when one tears linen: it is due to the fact that the air rapidly pushed on one side in front of the projectile, whether bullet or meteorite, quickly rushes back to fill the gap left in the rear.

The most rapid cannon-shots scarcely attain a velocity of 600 metres a second, while meteorites penetrate the air with a velocity of 40,000 or even 60,000 metres per second; and this increased velocity gives rise to phenomena, which, although insignificant where cannon-shots are in question, become very intense and important when we consider the case of the meteorite. With that velocity the air is at once raised to a temperature of from 4000° to 6000° C. The matter on the surface of the meteorite will be torn away by the violence of the gaseous friction produced, and will be vaporised at the same time by the heat. This is undoubtedly the origin of the smoke which meteorites leave trailing behind them.

We have, then, precisely as in the case of lightning, a long narrow column of air, which is expanded, not so instantaneously certainly as by lightning, but at all events in an extremely short time and through a great length. Under these circumstances we should have an explosion in one case as in the other: a clap of thunder followed by a rolling noise more or less prolonged. If a cannon-ball could have imparted to it a velocity of 100,000 metres per second, it would no longer whistle, it would thunder, and at the same time it would produce a flash, as of lightning, and would be instantly burnt up. M. Hirn depends upon this line of reasoning to show that meteoric thunder need not necessarily have anything to do with an actual explosion. He then points out that the intensity of the noise produced in every point of its trajectory

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depends, (1) on the height; (2) on the velocity of the meteorite; (3) on its size; and (4) on the configuration of the country over which it passes. He refers to the observation of Saussure that a pistol fired at a height of 5000 metres makes very little noise: he then points out that at a height of 100,000 metres the density of the air is reduced to the small value of 0·000,000,004 krg.; the temperature being supposed to be − 200° C. In such a medium as this a meteorite could produce no sound, although it might give out a very brilliant light, because its temperature and light depend not on the absolute value, but on the rapid change of density.

SIR JOSEPH WHITWORTH

ON Saturday night last, Sir Joseph Whitworth died at the English Hotel, Monte Carlo. In the department of mechanical engineering there is, perhaps, no greater name, and his career was one upon which his countrymen may well look back with pride and pleasure. He was born on December 21, 1803, at Stockport, where his father was a schoolmaster. At the age of twelve he was sent from his father's school to Mr. Vint's academy at Idle, near Leeds, where he remained until he was fourteen, when he was placed with his uncle, a cotton-spinner in Derbyshire. Here he made himself familiar with the construction and working of all the machines then used in cotton-spinning. If he had chosen, he might perhaps have inherited his uncle's property, but he was already conscious of the true bent of his genius, and after six years' service, being unable to emancipate himself in a more regular manner, he ran away to Manchester. At Manchester he remained for four years, working in the shops of Messrs. Crighton and other employers, and obtaining a thorough mastery of the methods of manufacturing cotton-machinery. Recognising the necessity of wide experience, he went to London when he had secured all the practical knowledge that could be obtained in his special line at Manchester, and he was fortunate enough to be employed by Maudslay, who soon learned to appreciate his exceptional gifts, and took him into his own private workroom, and placed him next to Hampson, the best workman in the establishment. From Maudslay's, Mr. Whitworth went to Holtzapfel's, and afterwards to Clements's, where Babbage's calculating-machine was being constructed. During his residence in London, Mr. Whitworth began the splendid series of inventions which were to secure for him the foremost place among the mechanical engineers of his period. His first important self-imposed task was to construct the true plane, by which tool-makers might be enabled to produce, for all kinds of sliding tools, surfaces on which the resistance arising from friction would be reduced to a minimum. The work to be achieved was one of immense difficulty, and his fellow-workman, Hampson, used to laugh at him for having undertaken an impossible job. Mr. Whitworth, however, was a man of extraordinary tenacity of purpose, and did not allow himself to be discouraged. At last he succeeded, and showed his friend the perfect plane he had produced. "You've done it," said Hampson, who was astounded by a result which he had always thought to be beyond the reach of human effort.

In 1833, at the age of thirty, Mr. Whitworth, feeling that he might now safely trust to his own energies, returned to Manchester and opened a shop for the manufacture of engineers' tools. He was far from thinking that his first triumph had given the full measure of his powers. Already he had been working at another very complicated problem—how to do away with the inconveniences caused by variations in the pitch and thread of the screws used in the construction of machinery. In this enterprise he was as successful as in his first great undertaking. Obtaining specimens of the screws made by leading manufacturers, he constructed one which, without being exactly like any one of those before him, was the average of them all. It was everywhere accepted, and its introduction marked an era in the history of the manufacture of machinery. The advantage derived from the invention is that every screw of the same diameter has now a thread of the same pitch and of the same number of turns to the inch, and that all screws of the same size are interchangeable. His next achievement was the construction of an instrument capable of measuring the one-millionth part of an inch. This instrument was so delicate that when a steel bar 3 feet in length was warmed by momentary contact with a finger-nail, it at once indicated the expansion due to this slight cause.

As a maker of engineers' tools Mr. Whitworth of course soon became famous, and in 1853 he was sent to America as one of the Royal Commissioners to the New York Exhibition. Afterwards he drew up a remarkable report on American manufacturing industry. On his return to England it was suggested by the late Lord Hardinge that the great mechanician, whose fame was now firmly established, should be asked by the Government to design and produce machinery for the manufacture of rifles for the army. The rifles at that time issued to the army were carefully examined by him, and he decided that if his services were to be of any avail it would be necessary for him to determine the form and dimensions which would produce the best results. With an alacrity very unusual in such matters, the Government consented to erect in his private grounds at Rusholme, near Manchester, a shooting-gallery 500 yards long. Here Mr. Whitworth laboured assiduously, trying many kinds of experiment, and at every stage of his progress making absolutely sure of his ground before advancing a step towards fresh conclusions. The result of his investigations was to revolutionise the manufacture of rifles. As the *Times* has said, "he determined, by absolute and precise experiment, the effects of every conceivable pitch and kind of rifling, and of every length of projectile, from the sphere to one of twenty diameters in length; and he settled once for all the conditions of trajectory and of accuracy of flight." The significance of his efforts began to be understood by every one when, at the first Wimbledon meeting, Her Majesty fired the first shot from a Whitworth rifle, placed on a mechanical rest sliding upon true planes. At 400 yards' range the bullet struck the target on its vertical diameter, one inch and a quarter above the intersection of the horizontal. What he established with regard to rifles he found to be in the main true with regard to weapons of a larger calibre, and he proved the importance of this fact by constructing a series of magnificent cannon.

In the course of his inquiries as to the principles which ought to be observed in the manufacture of rifled small arms and ordnance, Mr. Whitworth became penetrated by the conviction that a new material must be provided, since mild steel was apt to be rendered unsound by the imprisonment of escaping gases during the process of cooling from the molten state. He solved the problem by using great hydraulic presses for the squeezing of the molten metal in the act of cooling, so that the particles might be brought into closer contact and the gases liberated. The steel produced by this method is remarkable for its lightness, strength, and tenacity, and is largely used in the construction of boilers, screw-propeller shafts, and for other purposes.

In 1869 Mr. Whitworth was created a baronet, and he had already been for some years a Fellow of the Royal Society and a D.C.L. of Oxford. He had amassed wealth, and thoroughly appreciated all the advantages it secured for him. He was, however, a man of enlightened ideas and generous impulses, and early in 1869 he did splendid service to mechanical and engineering industry by founding the Whitworth Scholarships, which

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